The Parity Conservation Law: Still Alive!?

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This is a brief note for "pedestrians," which is devoted to the explanation of recent ideas of G. Ziino, A. Barut, D. V. Ahluwalia, and myself in the theory of neutral particles.

A number of articles discussing the parity violation effect is enormous. In yet another good popular article of the series "Fisica y Historia" Dr. Felix Valdez (Guanajuato, Mexico) presented a wide panorama for a general auditorium of the questions connected with the concept of the parity and its non-conservation, expressing the ideas that have prevailed in the brains of physicists in the last thirty years. However, another alternative already exists to the conclusion that the author of [1] defends on the basis of the results of the experiment of Yang and Lee [2]. I am convinced that the interpretation of that experiment, by way of physical laws is not being invariant with respect to the parity operation, can be misleading. Yet we don't know much about "the world through the looking glass."

Based on articles that have been published over the last few years in scientific journals by Profs. Ziino [3], Barut [4], Ahluwalia [5] and myself [6, 7, 8], I would like to present a framework that rejects the interpretation previously presented. Taking into account the goals of the journals ("Journal of Theoretics" and "Revista de Fisica — UNISON, Mexico) where I submitted two versions of the paper (English and Spanish), the propagation of physics for the young generation and making progress in the unification of physics through theoretical ideas, I will try to make the presentation as accessible as I am able, (on the B. Sc. and M. Sc. level) but mathematically rigorous.

Beforehand, let us remind ourselves of the Dirac equation, which describes charged particles in the relativistic frameworks. It has been known for every physicist:

$$[i\gamma^\mu \frac{\partial}{\partial x^\mu} - m]\ \psi(x^\mu) = 0 \qquad (1)$$

In this formulae γ^μ are 4 x 4 matrices that give the most simple representation of hypercomplex numbers from the mathematical viewpoint; m is the mass of the particles with the intrinsic angular momentum $\hbar/2$, the electron and the positron; $\psi(x)$ is the field (wave) function, i.e. we use the well-accustomed notation of practically all of the books on quantum theories. The Einstein rule is implied, namely, the summation in the indices which are repeated ($\mu = 0 \ldots 3$). From the above equation after one introduces the interaction with a 4-vector potential in it, the quantum-electrodynamic processes (i. e. the processes with elementary particles) can be calculated on using the perturbation theory.

Since long ago Ziino for the first time considered (1989, ref. [3]) an equation, which is similar to the one that Dirac deduced, but with the opposite sign in the mass term. The latter was proposed by Prof. M. Markov [9], the author of the well-known idea of friedmons. If the equa-tions are considered separately, the difference in the sign doesn't have any physical significance, which is the consequence of the CPT theorem in the theories for charged particles, the theorem dealing with discrete symmetries of space inversion, charge conjugation, and time reversal. This also can be seen in a simple way, by means of verification of the invariance of the fermion current in the quantum electrodynamics, with respect to transformation with the $\gamma^5 = i\gamma^0\gamma^1\gamma^2\gamma^3$ matrix.

However, those two equations can provide a theoretical construction of neutral particles, such as the neutrino when they are considered jointly. Ziino and Barut used the matrix g_5 as the matrix for charge conjugation. This means that the conjugation for all of the system, which consists of a fermion and a 4-vector potential. The Dirac function and its conjugate function (of an antifermion) obey the Dirac equations with the opposite signs for the mass term. Then, the self/anti-self charge conjugate states are automatically chiral states $x_f^{ch} = \frac{1-\gamma^5}{\sqrt{2}}\Psi_f$ and $x_f^{ch} = \frac{1+\gamma^5}{\sqrt{2}}\Psi_{\bar{f}}$. Nevertheless, they continue being massive. Ziino and Barut discovered that in the framework of this formulation:

- The problem of the missing right-handed neutrino (anti-clockwise if one sees a particle that is moving towards the observer) is absent. The image of the β process, $n \rightarrow p + e^- + \bar{\nu}_e$ $\frac{1}{2}$, has to be identified with the process that indeed occurs in nature, $\bar{n} \rightarrow \bar{p} + e^{+} + \nu_e$.

- The parity operation is divided naturally to the external parity corre-sponding to the change $\vec{x} \rightarrow -\vec{x}$ and the internal parity (which are defined in accordance with the selection of the Lorentz group representation and the dynamic properties of the particle).
- The Lagrangian in the theory with massive neutrinos is invariant with respect to both parts of the parity operation. This shows a great divergence from the model of Glashow, Salam, and Weinberg (GSW). However, in a particular case, one could describe the V-A electroweak phenomenology. It is a consequence of this non-invariance of the weak processes with respect to the external parity, that one cannot be considered as the true space-inversion operation for the ($\frac{1}{2}$, 0) $\oplus$ (0, $\frac{1}{2}$) Lorentz group representation.
- In the massless limit, one recovers the Weyl theory for two-component neutrinos.

In refs. [5, 6, 7, 8] other types of bispinors were used, in fact the Majorana spinors [10], which differ from (although they are connected with) the Dirac ones. Authors of those works arrived at the same conclusion as their predecessors and found other interesting theoretical features which were missed in refs. [3, 4]. For example, it was demonstrated that one can build the field operator which would contain *four* Majorana-like states and would preserve the parity as the theory which follows from the Barut-Ziino Lagrangian.[I] New equations (cf. with [9]) in the coordinate space are:

$$i\gamma^{\mu}\partial_{\mu}\lambda^{S}(x^{\mu}) - m\rho^{A}(x^{\mu}) = 0\,, \quad i\gamma^{\mu}\partial_{\mu}\lambda^{A}(x^{\mu}) + m\rho^{S}(x^{\mu}) = 0\,, \qquad (2)$$
$$i\gamma^{\mu}\partial_{\mu}\rho^{A}(x^{\mu}) - m\lambda^{S}(x^{\mu}) = 0\,, \quad i\gamma^{\mu}\partial_{\mu}\rho^{S}(x^{\mu}) + m\lambda^{A}(x^{\mu}) = 0\,, \qquad (3)$$

where the momentum-space self (S) /anti-self (A) charge conjugate bispinors are defined from the beginning. The quantum states in this for-mulation are not the eigenstates of the parity operator as we have the property $\lambda^{S} \Leftrightarrow p^{A}$ and $\lambda^{A} \Leftrightarrow p^{S}$ with respect to this operation, nor are they the eigen-states of the helicity operator (as opposed to the Dirac bispinors which describe an electron and a positron)[II] . They are bi-ortonormal ones from the mathematical point of view. Also, considering the gauge interactions[III] one could see that although the neutrino (which can be massive) is a neutral particle with respect to the electric charge operator, it is not a neutral particle with respect to another operator of the charge, the so-called chiral charge Q^{ch}.[IV] These two operators of the charge anticommute what was mentioned by Barut and Ziino. Thus we are induced to accept that the electron and the neutrino are but different states of the same object; when in the free state they cannot interfere each other (compare with the model of CSW where also a left-handed electron and a left-handed neutrino form a doublet).

From the group-theoretical viewpoint this construct represents a type of the Lorentz-invariant model (of the Wigner type)[11]. Wigner discovered that the inversion sub-group could be formed in several ways, as either a 4-group, a dihedral group, or as a $C_2 x\, C_4$, and the discrete symmetry operators in the Fock quantum space could commute or anticommute.

These ideas are, of course, are related to the concept of the so-called "mirror" particles. According to R. Volkas, R. Foot et al., Z. Berezhiani and R. Mohapatra, and Z. Silagadze [12] there may exist a mirror world "with the same microphysics as our own one but with opposite P- asymmetry".

From a philosophical viewpoint, this construct is as functional (it allows us to explain the old enigmas of the standard model) as beautiful (mathematically), as well as rational since it was built on the basis of the use of a minimal number of ingredients. That coincides the great Russian encyclopedist, I. A. Efremov's view (he was also the science fiction writer and had a second doctorate[IV] in the geological sciences): "what is beautiful is functional, what is functional is beautiful" (I. A. Efremov,"Leaf of Razor").

In conclusion: the idea of a parity violation in the electroweak interac-tions, perhaps will be left only as a historical memory in the same manner as flageston idea; an idea which the great Russian scientist M. V. Lomonosov denied and experimentally disproved in the XVIII century. Likewise the idea of a violation of the energy conservation as expressed by Dirac! Was displaced by W. Pauli's proposal of a new particle: the neutrino. Who knows what new points of view will help in resolving the apparent con-tradictions between the Copenhagen School and those such as L. de Broglie, A. Einstein, N. Rosen, B. Podol'sky, M. Sachs, and others who have criticized it.

Although in a theoretical sense, I believe that the idea of invariance of the operators that corresponds to the dynamic variables with respect to the Parity operation is a very attractive theoretical idea in the sense that the parity violation is "fictitious" as we observe only a part of the relevant processes. But in philosophiae naturalis, experimental validation will always have the last word.

Annotations:

I. Reading below, please, remember that the field operators contain two sets of quantum states, for a particle and its antiparticle.

II. The helicity operator is connected with the concept of the spin, a discrete phaseless variable that is defined for the field functions in each representation of the Lorentz group. The physical sense of that operator is that it defines projections of the intrinsic angular momentum to the direction of the motion.

III. The reader can find many articles where the gauge invariance is explained in detail on the accessible level, e.g., J. Enrique Barradas, Revista de Fisica — UNISON, No. 20 *(1995)* p. 9.

IV. We learned recently that a similar idea was expressed by Prof. R. Marahak some time ago.

V. In Russia there are two doctorate degrees. Generally, the second degree is awarded after the defense of one's thesis if there is a proposed new direction of research.

References:

[1] J. F. Valdez, Revista de Fisica—UNISON, No. 20, Sept. 1995, p. 32.

[2] T. F. Lee and C. N. Yang, *Phys. Rev.* 104 (1956) 254.

[3] G. Ziino, Ann. Fond. L. de Brogue 14 (1989) 427; ibid 16 (1991) 343; *Int. J. Mod. Phys. A*, in press; also see E. Recami and G. Ziino, Nuovo Cim. 33A (1976) 205.

[4] G. Ziino and A. Barut, *Mod. Phys. Lett.* A8 (1993) 1011.

[5] D. V. Ahluwalia, M. B. Johnson, T. Goldman, *Mod. Phys. Lett.* A9 (1994) 439; D. V. Ahiuwalia, Int. J. Mod. Phys. A11 (1996) 1855.

[6] V. V. Dvoeglazov, *Rev. Mex. Fis. Suppl.* (Proc. XVII Simposium of Nuclear Physics. Oaxtepec, Mexico, Jan. 4-7, 1995) 41 Suppl. 1. (1995) 159.

[7] V. V. Dvoeglazov, *Int. J. Theor. Phys.* 34 (1995) 2467.

18] V. V. Dvoeglazov, *Nuovo Cimento* 108A (1995) 1467.

[9] M. A. Markov, ZhETF 7 (1937) 579, 603; *JINR* Communications D-1345, Dubna, 1963.

[10] E. Majorana, Nuovo Cim. 14 (1937) 171.

[11] E. P. Wigner, in "Group Theoretical Concepts and Methods in Ele-mentary Particle Physics" (Lectures of the Istanbul Summer School of Theoretical Physics, 1962, Ed. F.Gursey), Gordon & Breach, 1965, p.37.

[12] Z. Silagadze, *Phys. Atom. Nucl.* **55** (1992) 392; ibid **60** (1997) 272; hep-ph /9908208

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